Aloe-emodin-Loaded Microemulsion-Based Herbal Gel: Design, Optimization, and Therapeutic Evaluation for Diabetic Wound Healing

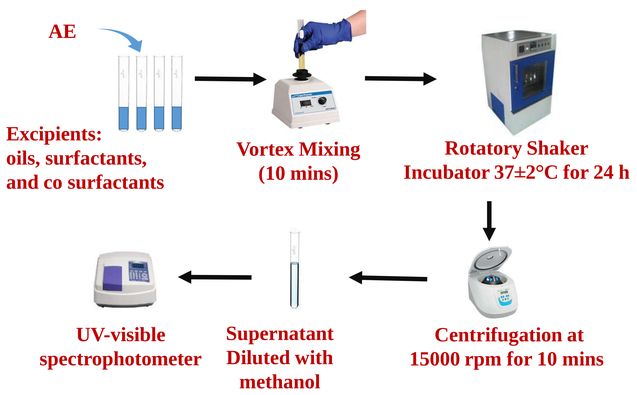
Pankaj Popli[1], Rajan Swami[1]
[1]Chitkara College of Pharmacy, Chitkara University, Rajpura, Punjab, India
Email: pankajpopli7@gmail.com

Abstract

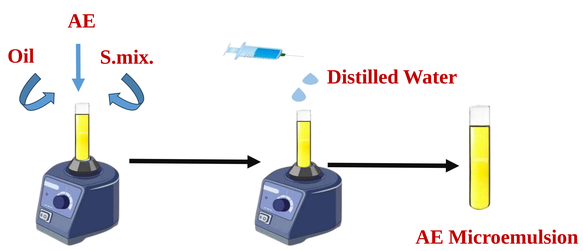
This study developed an Aloe-emodin (AE)-loaded microemulsion gel (AMEG) to improve AE's poor solubility and inadequate permeability for diabetic wound healing. Prepared with Capryol 90, Labrasol, Tween 80 and Transcutol P, using konjac glucomannan and Carbopol 940 as gelling agents, the optimized AMEG showed nanosized droplets, stability, sustained release and enhanced skin permeation. In diabetic rats, it markedly accelerated wound closure, reduced inflammation, promoted collagen deposition and achieved complete re-epithelialization, highlighting AMEG as a promising non-invasive therapy.

Methodology

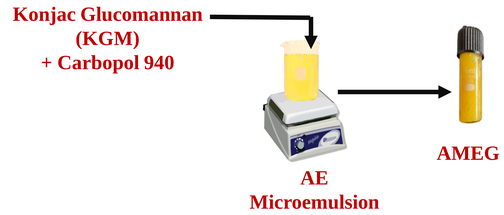
I. Selection of Oil, Surfactant, and Co-surfactant Based on AE Solubility



II. Formulation of AE Microemulsion



III. Preparation of AMEG



Results

Vehicles		Solubility (mg/ml)
Oils	Capryol 90	5.65±0.24
	Labrafil	5.05±0.21
	GTCC	4.86±0.65
	Medium chain triglycerides	3.67±0.21
	Maisine 35-1	3.36±0.19
Surfactant	Tween 80	50.03±0.12
	Labrasol	4.89±0.34
	Cremophor EL	2.98±0.78
Co-surfactant	Transcutol P	102.54±0.78
	PEG 400	86.98±0.23

Table 1: Solubility Profile of AE in oils, surfactants, and co-surfactants.

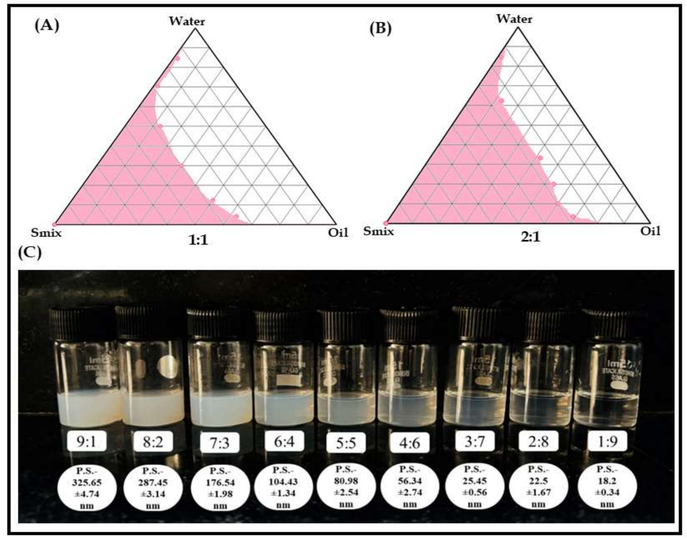


Fig 1: Pseudo-ternary phase diagrams with Smix 1:1 and 2:1. Clear = turbidity; shaded = ME. For Smix 2:1, ME blue tint observed up to 3:7 oil: Smix.

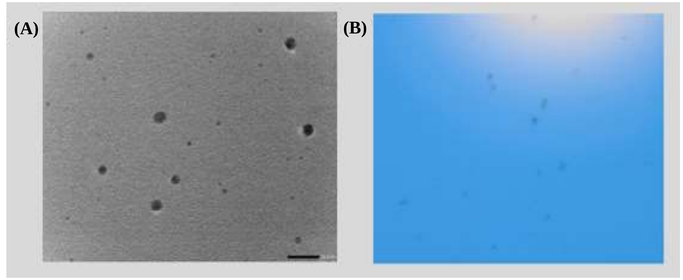


Fig 3: (A) TEM image of AME formulation (B) Staining test of AME formulation.

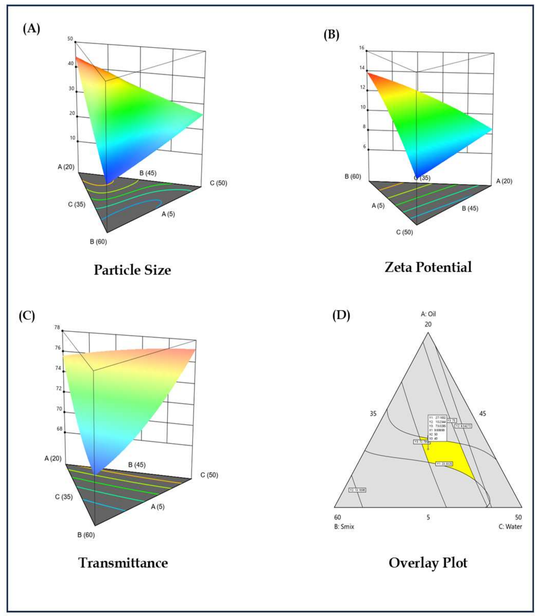


Fig 2: 3D surface plots of (A) particle size, (B) zeta potential, and (C) transmittance. (D) Overlay plot with yellow-shaded ME region.

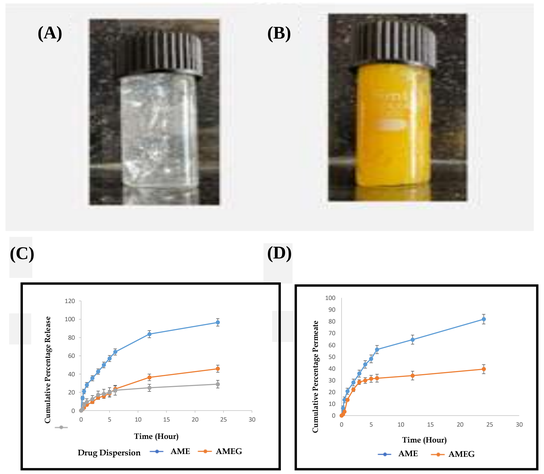


Fig 4: Viscosity & gel characteristics (A) Blank KCG, (B) AMEG, (C) In vitro drug release (drug dispersion, AME, AMEG), (D) Ex vivo permeation (AME vs. AMEG).

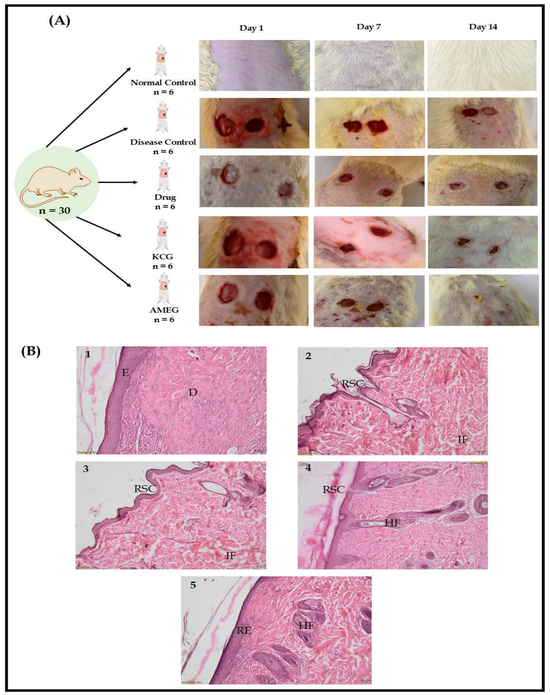


Fig 5: Efficacy study- (A) Wound contraction (B) Histology on day 14: (1) Normal, (2) Diseased, (3) Drug gel, (4) KCG, (5) AMEG.

Conclusion

AE, a natural phytoconstituent, possesses strong anti-inflammatory, antimicrobial, and antioxidant properties, but its topical use is restricted by poor solubility and BCS Class II status. An oil/Smix-based ME was developed, forming nanosized droplets that improved skin diffusion compared to the unformulated drug. Incorporation of KGM as a gelling agent enhanced structural stability and imparted wound-healing activity. The optimized AEMEG shows potential in diabetic wound ulcer management, emphasizing MEs as effective carriers and KGM as a multifunctional excipient.

References

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